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TECHNICAL REPORT

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# NON-CAKING FREEZE DRIED APPLESAUCE

by

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Project reference: 1G762713AO34  
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NATICK LABORATORIES  
Natick, Massachusetts 01760



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<p>A study was initiated to develop an applesauce which resists caking when subjected to elevated temperatures such as 37.7°C. for 2 weeks and/or 57°C. for 3 hours as required by NASA. Juice was extracted from McIntosh apples at different levels ranging between 15.8 and 77.0 percent by weight. The following results were obtained: 1) The degree of caking of the freeze dried applesauce powder was correlated with the amount of juice extracted. 2) Correlations were established between the percentage of juice extracted and each of the following: bulk density, soluble solids and reducing sugars of the applesauce powder. 3) Reducing sugars appear to be the factor contributing most significantly to the caking with the higher reducing sugar levels producing the higher degrees of caking. 4) Flavor and texture of the rehydrated applesauce powders were adversely affected by higher juice extractions.</p>			

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Caking	8		7			
Apples	1,2		7,9		1	
Applesauce	1,2		7,9		1	
Freeze dried foods	1,2					
Dehydrated foods	1,2					
Frozen Foods	1,2					
Freeze drying			6			
Shelf life			7			
Sugars			6,7			
Reducing sugars			6,7			
Applesauce powder					2	
Powder					2	
Juices					2	
Fruit juices					2	
Extraction					8	
Reconstitution					8	

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## FOREWORD

Natural dehydrated fruit powders when packaged in flexible packages under vacuum and stored at elevated temperatures ( $37^{\circ}\text{C}$  or higher) solidify and become very difficult to rehydrate. Therefore, this work was undertaken to develop processing techniques for the production of natural fruit powders such as apple-sauce powder which resists caking upon storage at elevated temperatures and can be rehydrated readily with cold or hot water. Such a product can be used successfully in space missions and special high altitude flight feeding systems.

This work was performed under Project No. 1G762713A034, Military Food Service and Subsistence Technology and National Aeronautics and Space Administration Customer Order No. T-20541-G, Food Packages and Containers for Manned Space Flights.

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## ABSTRACT

A study was initiated to develop an applesauce which resists caking when subjected to elevated temperatures such as 37.7°C. for 2 weeks and/or 57°C for 3 hours as required by NASA. Juice was extracted from McIntosh apples at different levels ranging between 15.8 and 77.0 percent by weight. The following results were obtained: 1) The degree of caking of the freeze dried applesauce powder was correlated with the amount of juice extracted. 2) Correlations were established between the percentage of juice extracted and each of the following: bulk density, soluble solids and reducing sugars of the applesauce powder. 3) Reducing sugars appear to be the factor contributing most significantly to the caking with the higher reducing sugar levels producing the higher degrees of caking. 4) Flavor and texture of the rehydrated applesauce powders were adversely affected by higher juice extractions.

## INTRODUCTION

A study was initiated to develop a dehydrated applesauce which meets the current requirements of NASA space foods. Such a product when placed in a flexible package under pressure ( $105 \times 10^3$  Pa) and subjected to elevated temperatures (i.e.,  $57^\circ\text{C}$  for 3 hours and/or 2 weeks at  $37.7^\circ\text{C}$ ) should not cake. To date, all available dehydrated applesauces failed to meet such requirements.

McIntosh apples were processed as follows: Peeling, coring, dicing, sulfiting, blanching, mechanical pressing (to extract the juice at 9 different levels ranging from 15 to 77 percent by weight), freezing, freeze drying, grinding, addition of sucrose and malic acid, and packaging. The results showed the following: 1) Caking occurred in samples where less than 45 percent of the juice was extracted, whereas no caking was observed in samples with higher juice extraction; 2) Technological evaluation for flavor, color, and texture of reconstituted samples with 45 to 55 percent juice extraction indicated acceptable quality whereas higher juice extraction adversely affected the quality; 3) Definite correlation was established between the degree of juice extraction and each of the following: Brix value, reducing sugars, bulk density and degree of caking; 4) Natural occurring sugars, especially reducing sugars, are contributing factors to the caking of dehydrated applesauce.

A high degree of food concentration may be attained by dehydration and conversion to powder form. This offers reduction in weight and volume, convenience in handling and packaging, and better stability when properly packaged and stored at room temperature. However, dehydrated fruit juices and pulps, due to their high content of hygroscopic sugars are often adversely affected by moisture, high storage temperatures and packaging conditions.

Properly packaged fruit powders often cake when stored at elevated temperatures, therefore this study was initiated to develop dehydrated applesauce which meets the current requirements of the National Aeronautic and Space Administration (NASA) space foods. Such a product when placed in a flexible package under pressure of  $105 \times 10^3$  Pa and subjected to elevated temperatures (i.e.,  $57^\circ\text{C}$  for 3 hours and/or 2 weeks at  $37.7^\circ\text{C}$ ) should not cake. To date, all available dehydrated applesauces failed to meet such requirements. Perhaps this is due to the high content of reducing sugars which were found to be predominant in apples. Mylne and Seegmiller (1950) indicated that apples contain 10.5 percent total sugars among which 8.6 percent are reducing sugars. Lopez, et al (1958) reported that total sugars in ten varieties of apples ranged from 10.5 to 13 percent among which 7 to 9.5 percent were reducing sugars.

## EXPERIMENTAL PROCEDURES

Fresh McIntosh apples were washed, peeled, cored and manually trimmed. They were diced to approximately 3/8 inch and sulfited by dipping the dice in a solution containing sodium metabisulfite resulting in approximately 300 ppm  $\text{SO}_2$  in the applesauce powder. The diced apples were then drained and blanched for 3 minutes in boiling water. The blanched dice were drained and divided into 13 lots where one lot was used as a control and each of the 12 remaining lots was pressed by means of a hydraulic press in order to extract specified amounts of juice. The percents by weight of juice extracted from each of the 12 lots respectively were: 15.8, 23.0, 26.1, 31.5, 34.6, 40.0, 46.6, 49.4, 55.2, 60.3, 66.0 and 77.0. Each of the pressed lots as well as the control was individually frozen at  $-20^\circ\text{F}$ . and then freeze dried at  $48^\circ\text{C}$ . Each lot was then ground so that 100 percent of the particles passed through a No. 10 sieve (0.20 cm openings).

Packaging and storage: 15 gms. of applesauce powder from each lot were separately placed in individual 8.9 x 17.8 cm bags made of a four-ply laminate: 1.0 mil polyethylene, 2.0 mil Aclar, 0.75 mil Mylar, and 2.2 mil polyethylene. This procedure was repeated with the addition of 20 gms. sucrose and 0.2 gm. malic acid to the applesauce powder. Each bag was sealed under pressure of  $105 \times 10^3 \text{ Pa}$  as shown in Fig. 1. Bags from each lot were separately stored for 3 hours at  $57^\circ\text{C}$ . and for two weeks at  $37.7^\circ\text{C}$ .

Objective tests: AOAC methods were used in the determination of moisture, total sugars, reducing sugars and total acidity.

Bulk density was measured by placing a weighed amount of applesauce powder into a graduated cylinder and then tapping 50 times on a wooden surface after which the volume of the powder was recorded.

Subjective tests: Flavor, color and texture were evaluated by a panel consisting of ten experienced food technologists at the U. S. Army Natick Laboratories (NLAPS). The applesauce powder was reconstituted by mixing the following ingredients: 15 gms. pure applesauce powder + 20 gms. sugar (sucrose) + 0.2 gm. malic acid + 200 gms. water.

## RESULTS AND DISCUSSION

The effect of temperature on applesauce powder as shown in Fig. 2 illustrates considerable caking in samples made of apple dice where less than 49.4 percent by weight of the juice was extracted.

The addition of sugar (sucrose) to the apple powder did not affect the degree of caking, since no noticeable differences could be seen when compared with the powder alone. The degree of caking decreases as the amount of extracted juice increases. In addition caking adversely affected the rehydration of applesauce powder as shown in Table 1.

The data shown in Table 2 indicates a definite negative correlation between the degree of juice extraction and each of the following: bulk density, soluble solids, and reducing sugars of the applesauce powder after pressing. These data are further illustrated in Figs. 3, 4 and 5. As the bulk density decreased the caking decreased and when the soluble solids as well as the reducing sugars decreased the caking also decreased. However, malic acid did not seem to follow such a pattern.

Caking of applesauce powder at elevated temperatures may be due to the relatively low melting point of reducing sugars (such as glucose, levulose, mannose and xylose as compared with sucrose). Vitte et al (1952) stated that sucrose, glucose, levulose, mannose and xylose were identified in apples. Therefore the degree of caking could be attributed to the amount of reducing sugars present in the applesauce as they represent the major constituents of the soluble solids. This appears to be confirmed since the addition of sucrose to the powder did not seem to have a noticeable effect on the caking.

The results of the technological evaluation as shown in Table 3 indicate that samples with higher percentages of juice extraction received lower ratings for both flavor and texture.

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TABLE 1 - RECONSTITUTION OF APPLESAUCE  
POWDER AS AFFECTED BY CAKING

Percent by weight of juice extracted	Time in minutes
Control	No reconstitution *
15.8	No reconstitution *
23.0	" "
26.1	" "
31.5	" "
34.6	" "
40.0	15 - 30
46.6	5 - 10
49.4	3 - 5
55.2	1
60.3	"
66.0	"
77.0	"

\* Failed to reconstitute within 1 hour (caked).

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TABLE 2 - CHEMICAL ANALYSIS OF FRESH AND PRESSED APPLE DICE  
(PERCENT DRY BASIS) AND BULK DENSITY OF THE POWDER

Percent by weight of juice extracted	Fresh apple dice				Pressed apple dice			Appearance Powder	
	Reducing Sugars	Soluble Solids (Degrees Brix)	Malic Acid	Reducing Sugars	Soluble Solids (Degrees Brix)	Malic Acid	Bulk Density g/cc		
Control	70.7	87.0	2.3	--	--	--	0.241		
15.8	65.0	85.8	2.5	56.2	75.4	2.0	0.235		
23.0	73.1	87.8	1.8	56.1	70.4	2.1	0.238		
26.1	69.3	89.2	2.5	55.2	76.7	2.4	0.214		
31.5	65.4	91.0	2.1	52.8	75.3	1.9	0.223		
34.6	64.4	84.2	2.1	50.3	76.2	1.8	0.201		
40.0	66.8	84.7	1.6	49.8	69.3	1.9	0.213		
46.6	65.7	86.0	1.8	49.4	74.5	1.6	0.205		
49.4	67.8	90.6	1.8	46.8	67.7	1.7	0.196		
55.2	67.4	84.9	2.0	41.2	60.2	2.0	0.185		
60.3	64.6	83.0	2.3	42.1	52.8	1.8	0.197		
66.0	64.3	88.5	1.8	43.1	64.1	1.4	0.193		
77.0	66.5	85.9	2.2	42.9	56.9	1.9	0.160		

Correlation Coefficient (r) between percent by weight of juice extracted and bulk density = 0.95  
 " " " " " " soluble solids = 0.83  
 " " " " " " reducing sugars = 0.76

TABLE 3 - AVERAGE TECHNOLOGICAL PANEL RATINGS\* OF APPLESAUCE  
POWDER (RECONSTITUTED) AS AFFECTED BY JUICE EXTRACTION

Percent juice by weight extracted	Color	Odor	Flavor	Texture	Appearance
Control (0 extraction)	6.6	6.6	5.4	5.6	6.5
15.8	6.9	6.5	6.5	6.1	6.9
23.0	5.0	6.0	4.9	5.3	5.4
26.1	6.7	6.6	5.9	5.4	6.2
31.5	6.7	6.4	6.3	5.4	6.3
34.6	5.7	5.6	4.2	4.9	5.3
40.0	5.3	5.7	5.4	5.1	5.6
46.6	5.9	5.9	5.9	5.7	5.6
49.4	5.7	6.0	5.1	5.7	5.7
55.2	6.6	5.9	5.1	5.2	6.2
60.3	5.0	5.7	4.4	4.8	5.3
66.0	5.3	5.4	4.6	4.8	5.2
77.0	4.7	5.1	3.8	4.3	4.6

\* 1 = Extremely poor  
9 = Excellent

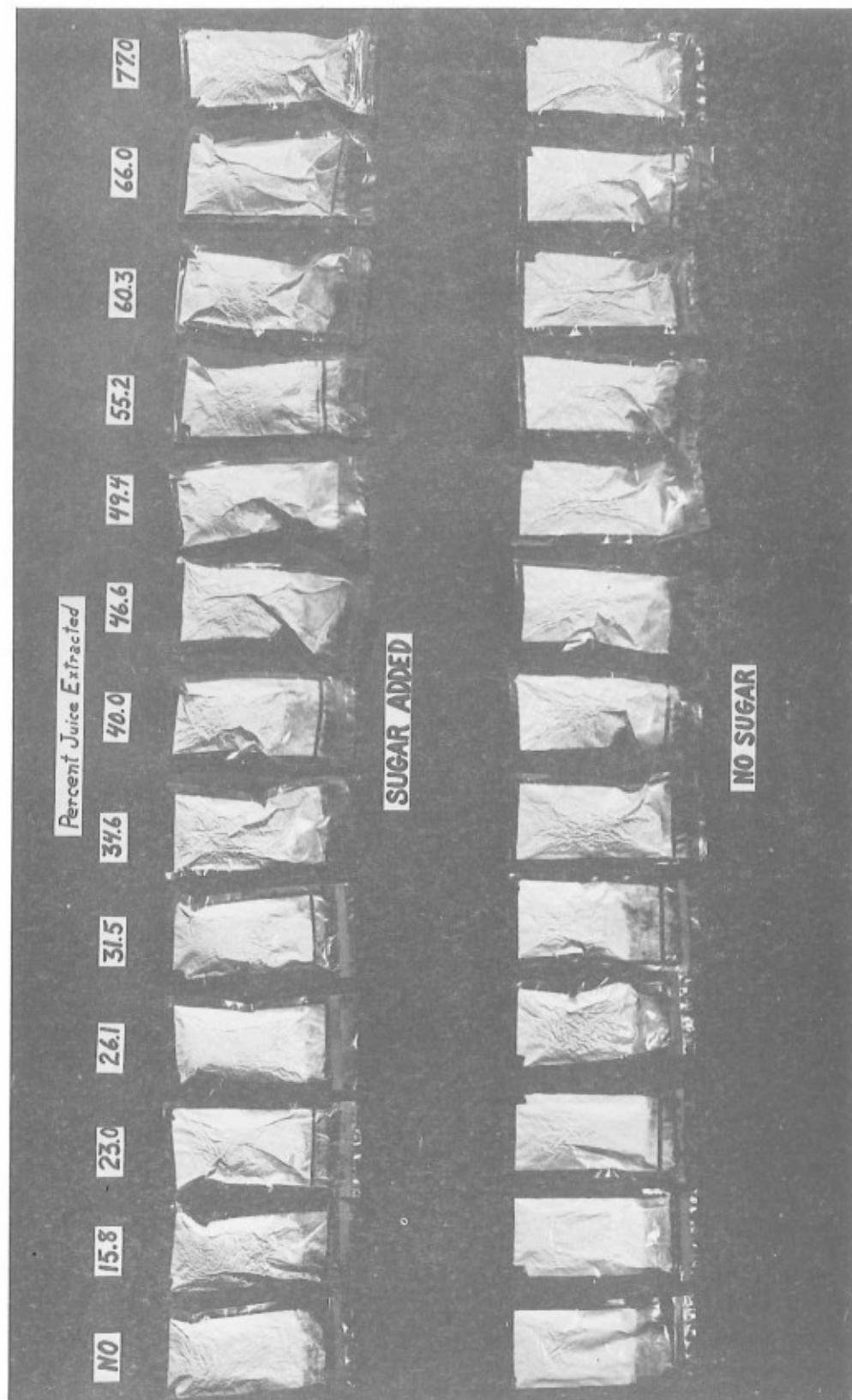


Figure 1 - Applesauce powder packaged in flexible packages under vacuum prior to storage at 37.7° for 2 weeks.

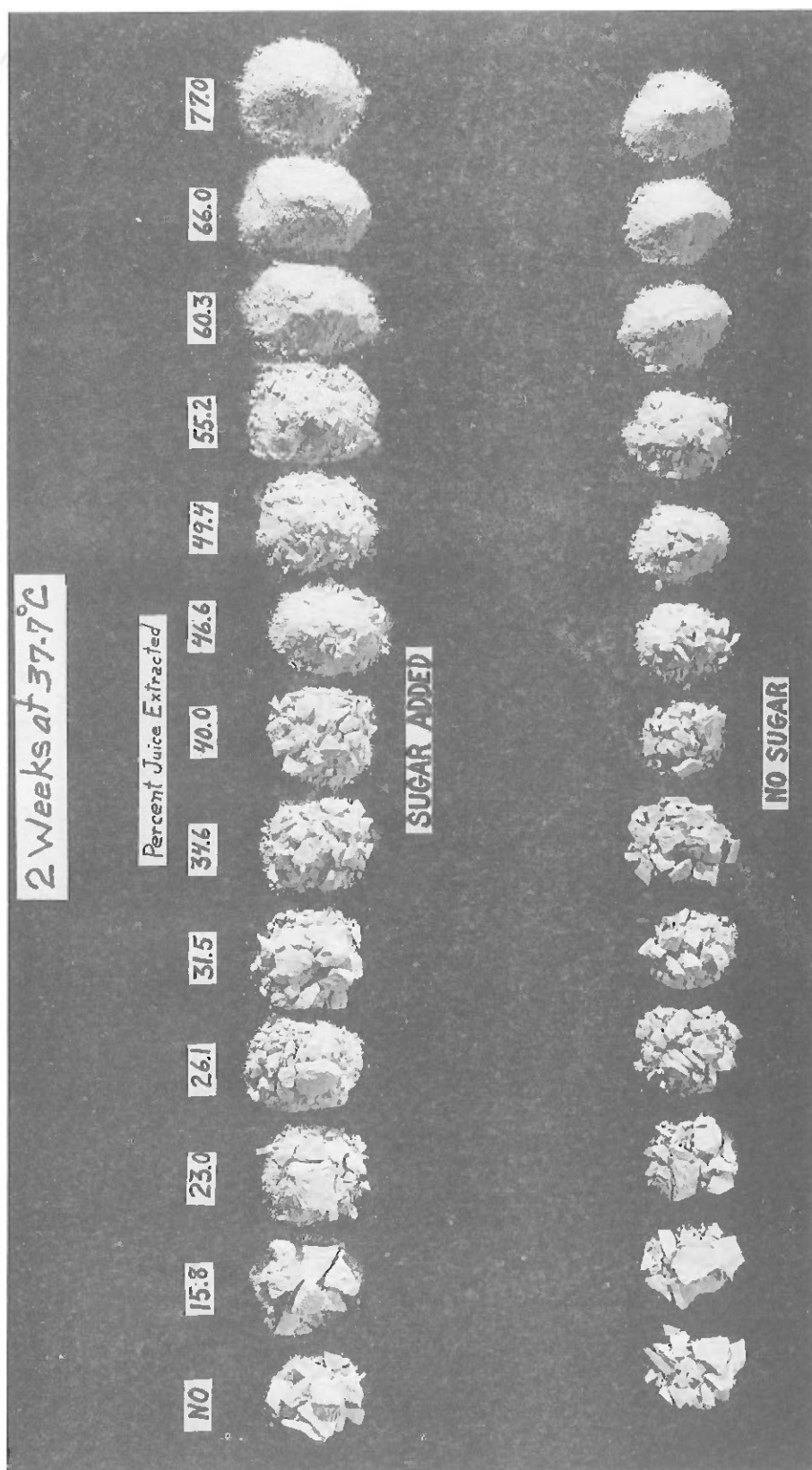
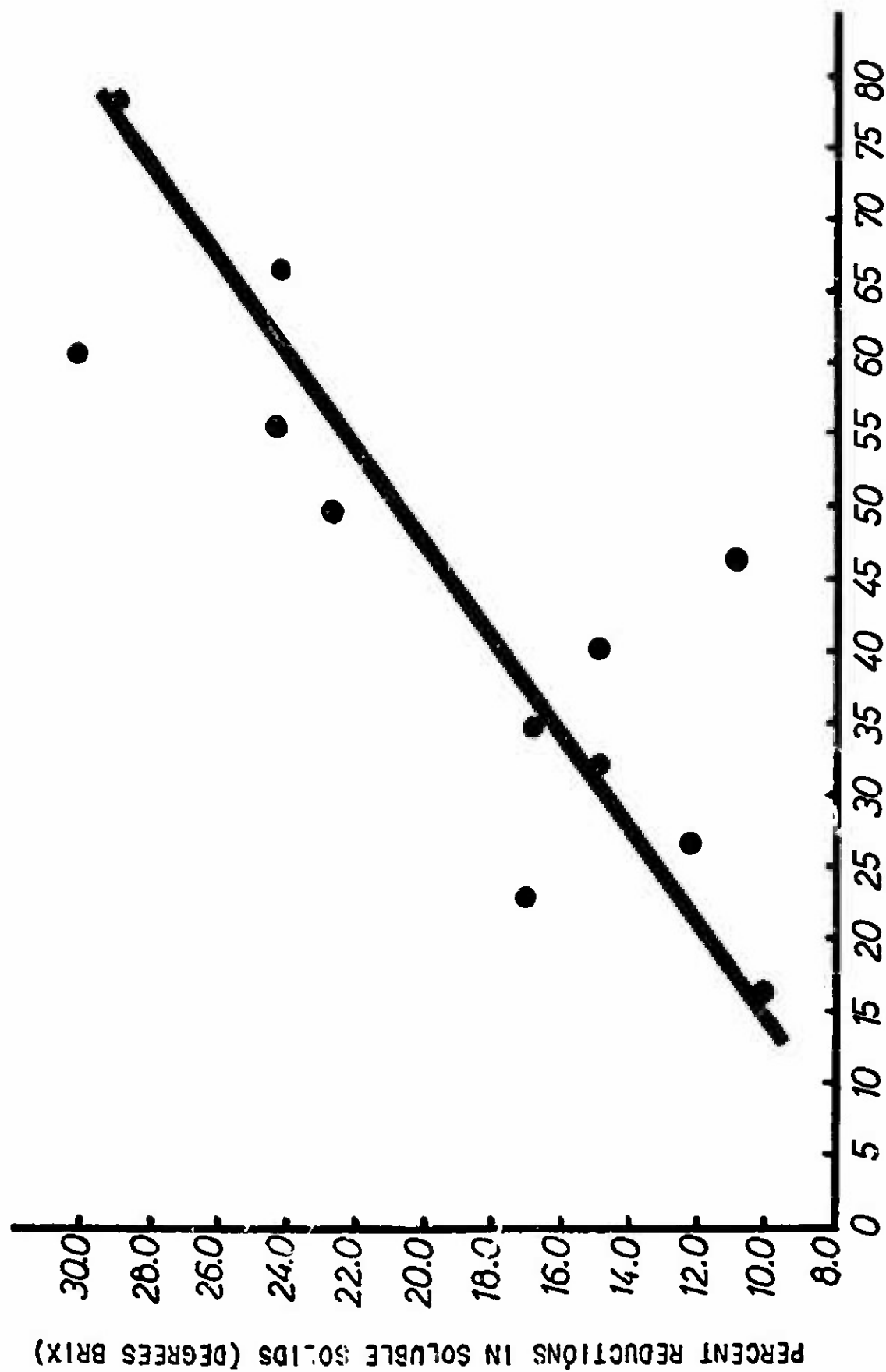


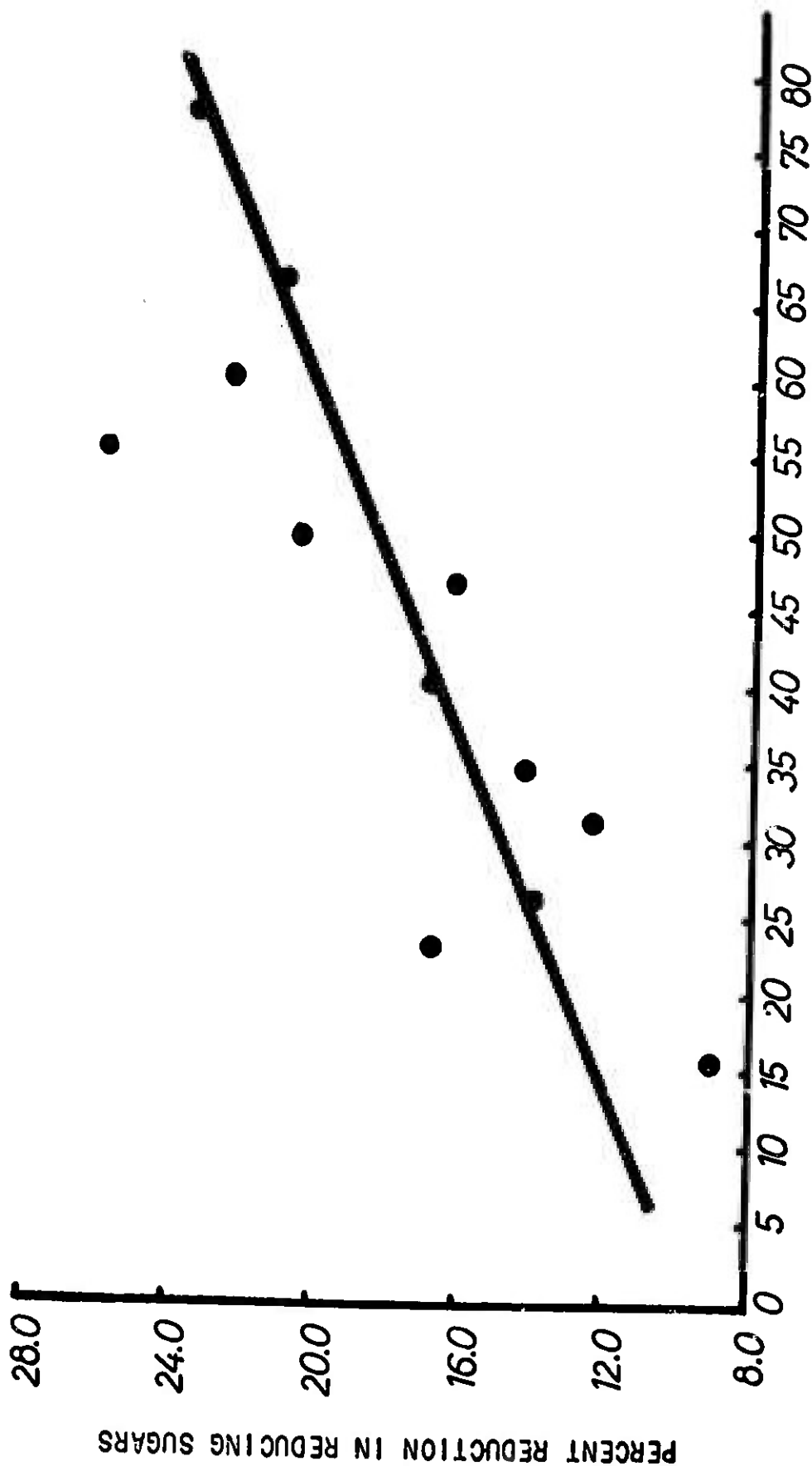
Figure 2 - Caking of applesauce powder as affected by juice extraction after storage at 37.7°C.



PERCENT BY WEIGHT OF JUICE EXTRACTED

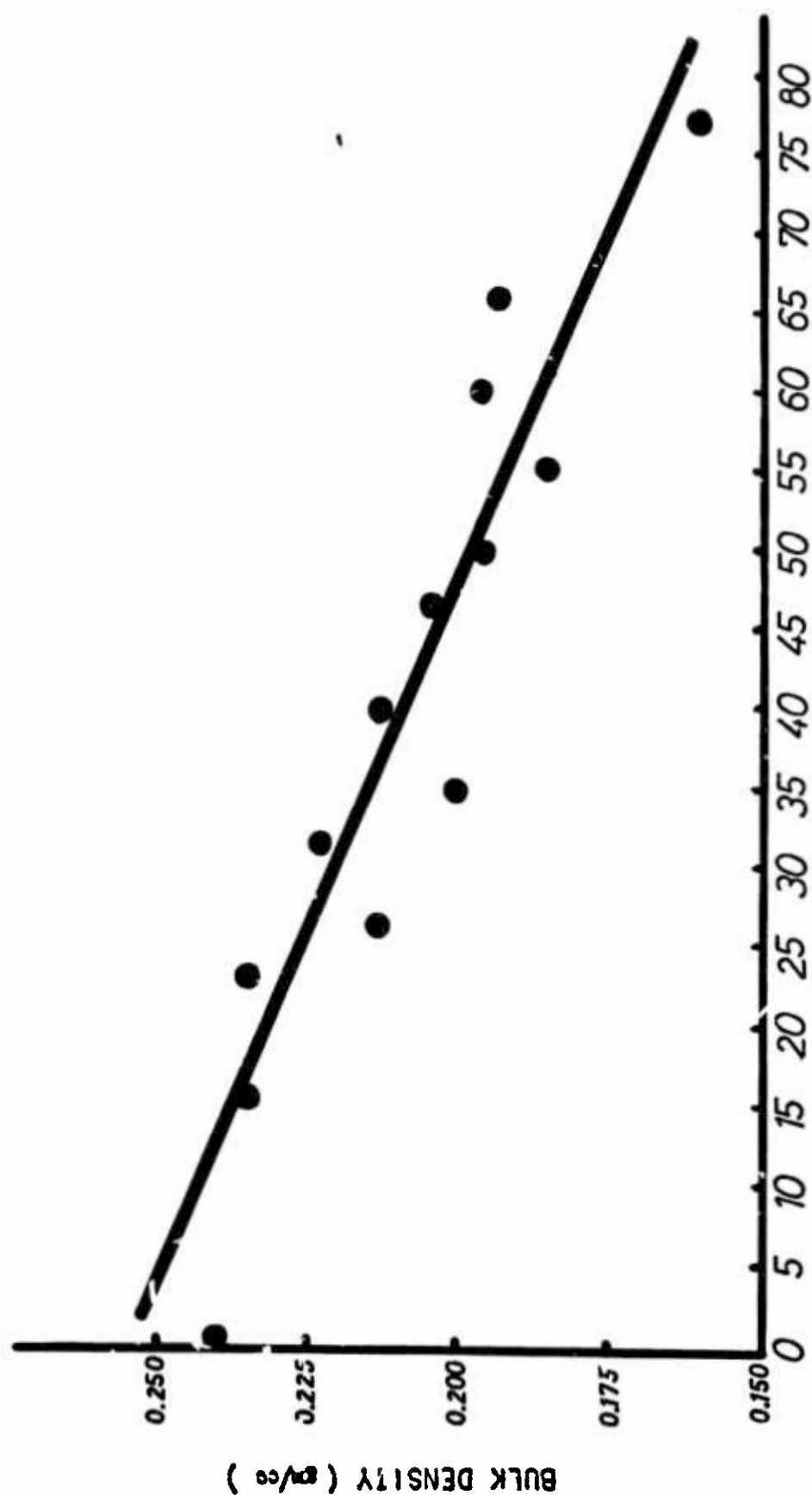
Figure 3 - Total soluble solids (degrees Brix) in applesauce powder as affected by juice extraction.





PERCENT BY WEIGHT OF JUICE EXTRACTED

Figure 4 - Reducing sugars in applesauce powder as affected by juice extraction.



PERCENT BY WEIGHT OF ICE EXTRACTED

Figure 5 - Bulk density of applesauce powder as affected by juice reaction.